vides sub-drop resolution for more accurate measurement and control. It provides free-flow detection. It can differentiate between aqueous and lipid solutions as well as other opaque solutions. It requires relatively low power usage and processing requirements. Detection of pendant drops (rather than falling drops) requires lower reading frequency to ensure that no drops are missed. Detection of pendant drops reduces the possibility that a drop will be missed due to tilting of the drip chamber. Positioning of optics at the higher drop-forming position reduces optical interference due to droplets or misting, which typically occur lower on the drip chamber internal walls. It allows a variety of specific configurations for optimal performance for specific or specialized applications.

[0238] Another embodiment is similar to previous embodiments except that it employs a digital camera to monitor the level of the fluid pool at the bottom of the drip chamber. As shown in FIG. **14**A, fluid pool **1403** is maintained in the lower part of drip chamber body **402**. Lower camera **1406** is directed generally horizontally, adjacent to and directed toward fluid pool **1403** so that the meniscus formed at the top surface of the fluid pool is within the field of view of the camera. Digital images obtained from the camera are processed by connected electronic or computer components to obtain a metric indicating the level or depth of the fluid pool.

[0239] It will be evident to one skilled in the art that many variations can be made to the present invention while maintaining its novel features and functionality. In particular, the various motive means, sensor means, and geometric variations of the embodiments described above may be used in various combinations to create additional embodiments. Further, the components used in the present invention may be fabricated from a range of materials, including various polymers, metals, ceramics, and natural substances, and manufactured by various means, including molding, machining, printing, forming, and others, while maintaining its novel features and functionality. Further, the orientations of components used in the drawings and descriptions herein has been chosen only the purpose of clarity of explanation.

[0240] Although the foregoing disclosure has laid out various embodiments of an apparatus for controlling the flow rate of a fluid into a patient's body, it is to be understood that this disclosure is intended to also cover the related methods for controlling the flow rate of a fluid into a patient's body which may readily be inferred by those of ordinary skill in the art from the apparatus embodiments disclosed.

[0241] The knowledge possessed by someone of ordinary skill in the art at the time of this disclosure, including but not limited to the prior art disclosed with this application, is understood to be part and parcel of this disclosure and is implicitly incorporated by reference herein, even if in the interest of economy express statements about the specific knowledge understood to be possessed by someone of ordinary skill are omitted from this disclosure. While reference may be made in this disclosure to the invention comprising a combination of a plurality of elements, it is also understood that this invention is regarded to comprise combinations which omit or exclude one or more of such elements, even if this omission or exclusion of an element or elements is not expressly stated herein, unless it is expressly stated herein that an element is essential to applicant's combination and cannot be omitted. It is further understood that the related prior art may include elements from which this invention may be distinguished by negative claim limitations, even without any express statement of such negative limitations herein. It is to be understood, between the positive statements of applicant's invention expressly stated herein, and the prior art and knowledge of the prior art by those of ordinary skill which is incorporated herein even if not expressly reproduced here for reasons of economy, that any and all such negative claim limitations supported by the prior art are also considered to be within the scope of this disclosure and its associated claims, even absent any express statement herein about any particular negative claim limitations.

[0242] Finally, while only certain preferred features of the invention have been illustrated and described, many modifications, changes and substitutions will occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention.

APPENDIX: LAMINAR FLOW IN CIRCULAR TUBES WITH MULTIPLE DIAMETERS

[0243] Laminar flow through a circular tube or pipe is described by:

$$Q = \frac{\Delta P \pi D^4}{128\ \mu \mathrm{L}}$$

where Q is the volumetric flow rate, ΔP is the pressure difference between the two ends of the tube, D is the inside diameter of the tube μ is the dynamic viscosity of the fluid, and L is the length of the tube.

[0244] This can be rearranged as:

$$Q = \frac{\Delta P}{R_f} \text{ where } R_f = \frac{128\ \mu \mathrm{L}}{\pi D^4},$$

analogous to Ohm's law in electronics, with R_f being the fluid resistance of the tube. If two or more tubes, possibly have different lengths and diameters, are connected in series the total flow resistance is simply the addition of the individual flow resistance, giving:

$$Q = \frac{\Delta P}{R_f(D_1, L_1) + R_f(D_2, L_2) + \ldots}$$

where R_f is considered a function of diameter and length. This formula may be applied, for example to determine the minimum flow resistance for an intravenous delivery where no occlusion is applied and an IV set tube and IV needle are connected in series.

[0245] The true value for ΔP in a gravity-driven infuser is determined by the head height from the top of the fluid surface in the container to the entry point on the patient, less the internal pressure of the patient's vein. Peripheral venous pressure for a prone or seated person is normally less than 1000 Pa. The pressure is thus given by:

$$\Delta P = \rho g h - P_v$$